AMBIENT AIR QUALITY IN WINDSOR AND VICINITY

ANNUAL REPORT 1987

FEBRUARY 1989

Environment Ontario

Jim Bradley
Minister

ISSN 0715-9536

AMBIENT AIR QUALITY IN WINDSOR AND VICINITY ANNUAL REPORT 1987

G. A. Grosse
Technical Support Section
Southwestern Region

February 1989

TABLE OF CONTENTS

TABLE OF CONTENTS - continued

SUMMARY

The Ministry's air quality monitoring program conducted in the Windsor area showed that some areas experience unsatisfactory levels of specific air pollutants. Levels of suspended particulates are unsatisfactory in west Windsor, in the immediate vicinity of the scrap metal operations of Zalev Brothers Limited and near the casting plant of the Ford Motor Company of Canada, Limited. In recent years levels of suspended particulates have increased near the casting plant. In the vicinity of the Zalev Brothers Limited suspended particulate levels were greater in 1987 than in 1986.

In addition to unsatisfactory levels of suspended particulates in west Windsor there are frequent occasions of unsatisfactory levels of total reduced sulphur compounds. Total reduced sulphur compounds tend to be malodorous. The elevated levels in west Windsor are associated with winds blowing from the direction of the steel industry located in the Zug Island area of Wayne County, Michigan. Elevated levels of iron in suspended particulate matter have been detected on the same days as elevated levels of total reduced sulphur compounds.

Excursions were again detected above the desirable ambient air quality criterion established for ozone. Ozone is the most abundant photochemical oxidant in ambient air. The elevated levels are largely a result of long-range transport of oxidants and precursor chemicals into the Windsor area. Ontario has established a special program to study the oxidant situation and to develop an appropriate control strategy. The U.S. Environmental Protection Agency is requiring individual states to develop and implement oxidant control strategies.

INTRODUCTION

The Ontario Ministry of the Environment operates a network of ambient air monitors in the Windsor area to measure levels of a number of pollutants that may adversely affect health, vegetation and the enjoyment of property. Data on the levels of pollutants are compared with Ontario's criteria for desirable ambient air quality. Data are also used to determine trends in air quality and therefore, the effectiveness of pollution abatement. As well, information is provided on the effects of specific sources of pollutants and for use in the formulation of strategies to control emission sources. In addition to the air monitoring conducted at fixed sites, mobile air monitoring units are sometimes used especially for intensified monitoring near specific emission sources. The air monitoring program is complemented by the Ministry's phytotoxicology surveys which determine effects of air pollutants on vegetation.

In July 1987 the Ministry and Environment Canada began a co-operative ambient air monitoring program for toxics and organics in Windsor. This program will provide information on the levels of inhalable particulate matter, hyrocarbons and toxics, such as polychlorinated biphenyls, dioxins, and chlorinated organics before and after the start-up of the refuse incinerators in Detroit. Some data from the joint monitoring program has been released in the report "Detroit Incineration Monitoring Program, Data Report #1, Windsor Air Sampling Site, July 1987 - November 1987", Environment Canada, Ottawa, Ontario.

This annual report deals specifically with ambient air quality data gathered from the Ministry's fixed monitoring sites in the Windsor area. Emphasis is placed on the data for 1987 but trends for data collected since 1980 are discussed. Detailed information on pollution abatement activities may be obtained from the Windsor District Office.

DESCRIPTION OF MONITORING NETWORK

The Ministry operates continuous and intermittent ambient air monitors at fixed sites throughout the Windsor area. Ideally, monitoring would be conducted at the same sites year after year in order to provide a historical trend for air quality. However, many stations have had to be relocated or terminated because of local interferences or changing land-use patterns. Nevertheless, the number of existing historical stations is deemed adequate to evaluate the long-term trend information.

The main monitoring station is located in the downtown area in order to evaluate air quality where emissions from motor vehicles and commercial establishments are most prevalent. There are a number of monitoring stations in west Windsor, which is close to a heavily industrialized portion of Wayne County, Michigan.

In the vicinity of Zalev Brothers Ltd. there are several monitoring stations that were established to better define the impact of emissions from the Company's scrap metal operations on neighbourhood air quality.

The location of the Ministry's monitoring stations in the Windsor area are indicated on Figure 1 and are described in Table A1 of Appendix 1.

The pollutants monitored at the various stations are listed in Appendix 1, Table A2. Ontario's criteria for desirable ambient air quality with respect to these pollutants and the prime factors supporting these criteria appear in Appendix 1, Table A3.

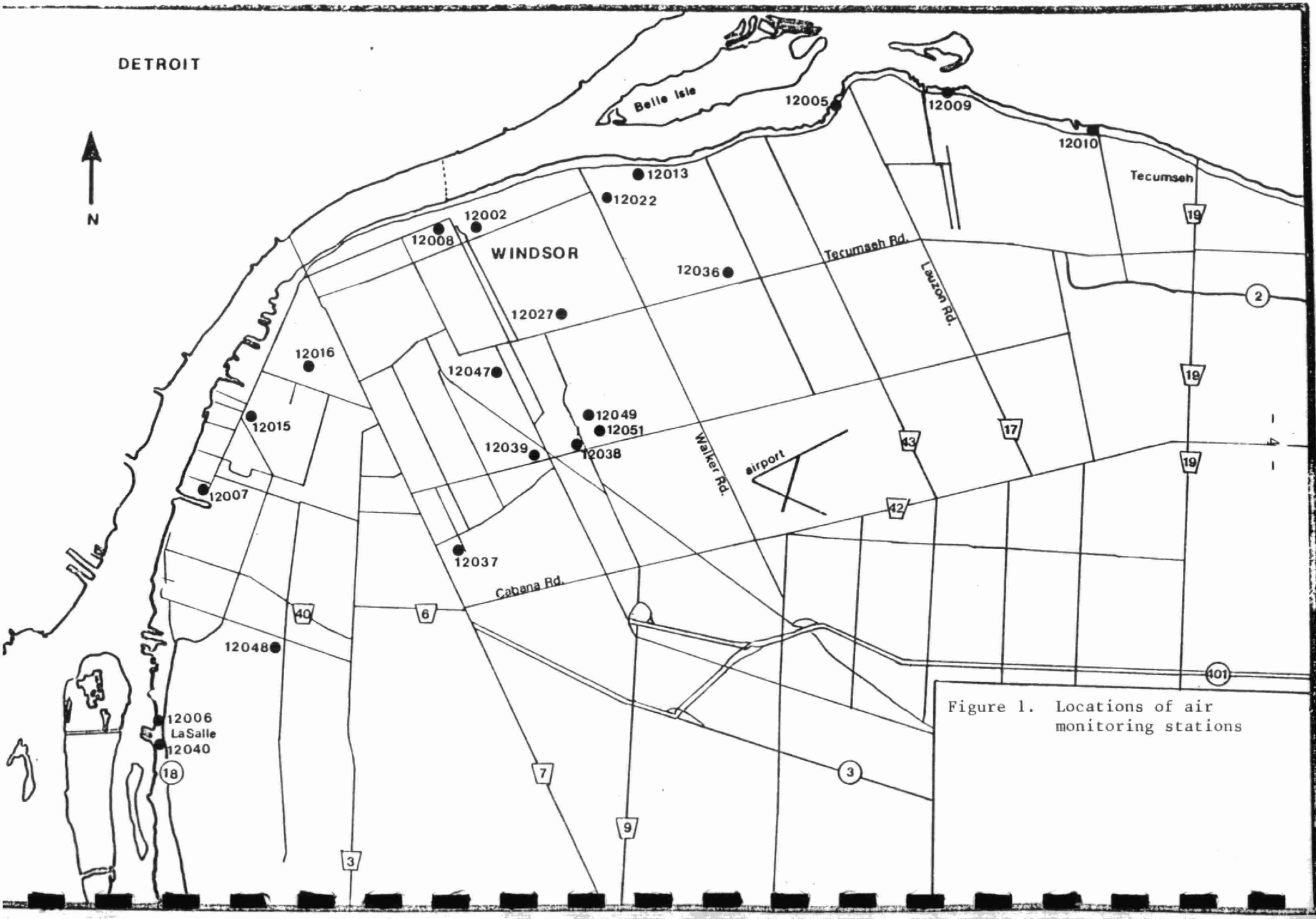


Figure 1. Locations of air monitoring stations

MONITORING AND PROGRAM RESULTS

PARTICULATES

The iron and steel industry, scrap metal operations and foundries, power generating plants utilizing fossil fuels and road traffic are primary sources of particulates that may adversely affect air quality in Windsor. Wind-blown particulates from open fields, sand and coal piles, roadways and roofs are also significant sources.

Measurements for particulates are reported as suspended particulates and soiling index. Levels of suspended particulates are determined by drawing measured volumes of air through a filter for 24 hours and subsequently weighing the quantity of particulates collected on the filter. The particulates trapped on the filters may also be analyzed for other parameters such as metals, sulphates and nitrates.

Soiling index is determined by measuring the difference in the amount of light transmitted through a filter before and after ambient air is drawn through the filter for one hour. The amount of light transmitted through the filter is affected by the quantity, size, shape and opaqueness of particulates retained on the filter. Light transmitted through the filter is measured by a photo-electric cell and the soiling index may be calculated immediately. This immediate availability of the soiling index in contrast with the time-consuming laboratory analysis required for total suspended particulate measurements has resulted in soiling index being used in the Air Pollution Index as an indicator of levels of suspended particulates.

Two criteria for desirable ambient air quality exist for total suspended particulate matter. One is 120 micrograms of suspended particulates per cubic metre of air (ug/m^3) averaged over a 24-hour period. The other criterion is an annual geometric mean of 60 ug/m^3. The criterion for 24-hours is based on impairment of visibility and adverse health effects associated with combined concentrations of sulphur dioxide and suspended particulates. The annual criterion is based on public awareness of suspended particulates and property damage.

During 1987, filters were exposed using Hi-Vol samplers at 17 sites in the Windsor area. At all sites, except station 12008, samples were collected on a frequency of every-sixth-day. At station 12008, sampling was conducted every day to provide information by which it could be determined if the every-sixth-day sampling schedule was representative of the whole year. A summary of total suspended particulate (TSP) data collected from 1980 through 1987 appears in Table 1A and 1B. Figure 2 shows the annual geometric mean and the percentage of excursions above the 24-hour criterion for the various monitoring stations during 1987.

The data from the every-day sampling schedule at station 12008 had a very similar annual geometric mean and frequency of excursions above the 24-hour criterion as can be calculated using only the every-sixth-day data for the same station. Hence the every-sixth-day schedule provided good representation of the complete year.

Figure 3 illustrates the average annual geometric mean for the eleven monitoring stations in operation since at least 1980. The eleven monitoring stations do not include stations added since 1980 such as the four stations that started near Zalev Brothers Ltd. in 1985 and 1986. Figure 4 illustrates the trend in frequencies of excursions above the 24-hour criterion for the eleven stations. The trend information indicates a reduction in particulate levels until 1983 and an increasing trend after 1983.

Table 1A Summary of Data for Total Suspended Particulates; Annual Geometric Mean Concentrations (ug/m^3)

Station	Year							
	1980	1981	1982	1983	1984	1985	1986	1987
12002	77	69	62	53	50	50	61	58
12005	55	45	45	36	38	41	48	42
12006				49	48	56	67	66
12007					(67)	73	72	68
12008	71	58	55	53	57	59	63	68
12008S			58	60	61	59	68	68
12009	58	46	46	36	36	43	45	47
12010	47	40	39	31	33	42	53	41
12013	75	65	68	65	66	77	85	84
12015	108	87	70	59	79	90	86	89
12016	83	67	63	50	54	56	68	66
12036	70	55	53	49	49	53	58	58
12037	60	49	39	42	47	46	55	44
12038						(79)	69	81
12039	71	71	53	49	50	54	62	65
12047						46	49	52
12049						57	56	62
12051							(58)	64

( ) - Annual geometric mean is based on data not representative of total year.

Annual criterion for desirable ambient air quality is 60 ug/m^3

Data for station 12008S are every sixth day sampling results extracted from the daily sampling data for station 12008.

Table 1B Summary of Data for Total Suspended Particulates; Percentage of Values Above 24 Hour Criterion

Station	Year 1980	1981	1982	1983	1984	1985	1986	1987
12002	19	9	11	4	0	2	2	2
12005	2	2	2	0	2	2	0	2
12006				6	0	2	0	7
12007					(7)	15	14	4
12008	12	6	4	2	5	4	7	10
12008S			4	4	6	9	12	8
12009	9	0	4	0	0	4	0	3
12010	0	0	0	0	0	2	6	0
12013	15	5	18	16	14	18	25	28
12015	46	16	8	3	22	24	13	26
12016	20	6	5	3	5	5	16	8
12036	13	2	2	0	2	2	0	3
12037	2	2	2	0	2	2	0	2
12038						(15)	9	13
12039	8	3	6	2	0	2	0	8
12047						2	0	0
12049						6	2	5
12051							(7)	11

( ) - Percentage of values above 24 hour criterion based on data not representative of total year.

Data for station 12008S are every sixth day sampling results extracted from the daily sampling data for station 12008.

24-hour criterion for desirable ambient air quality is 120 ug/m^3.

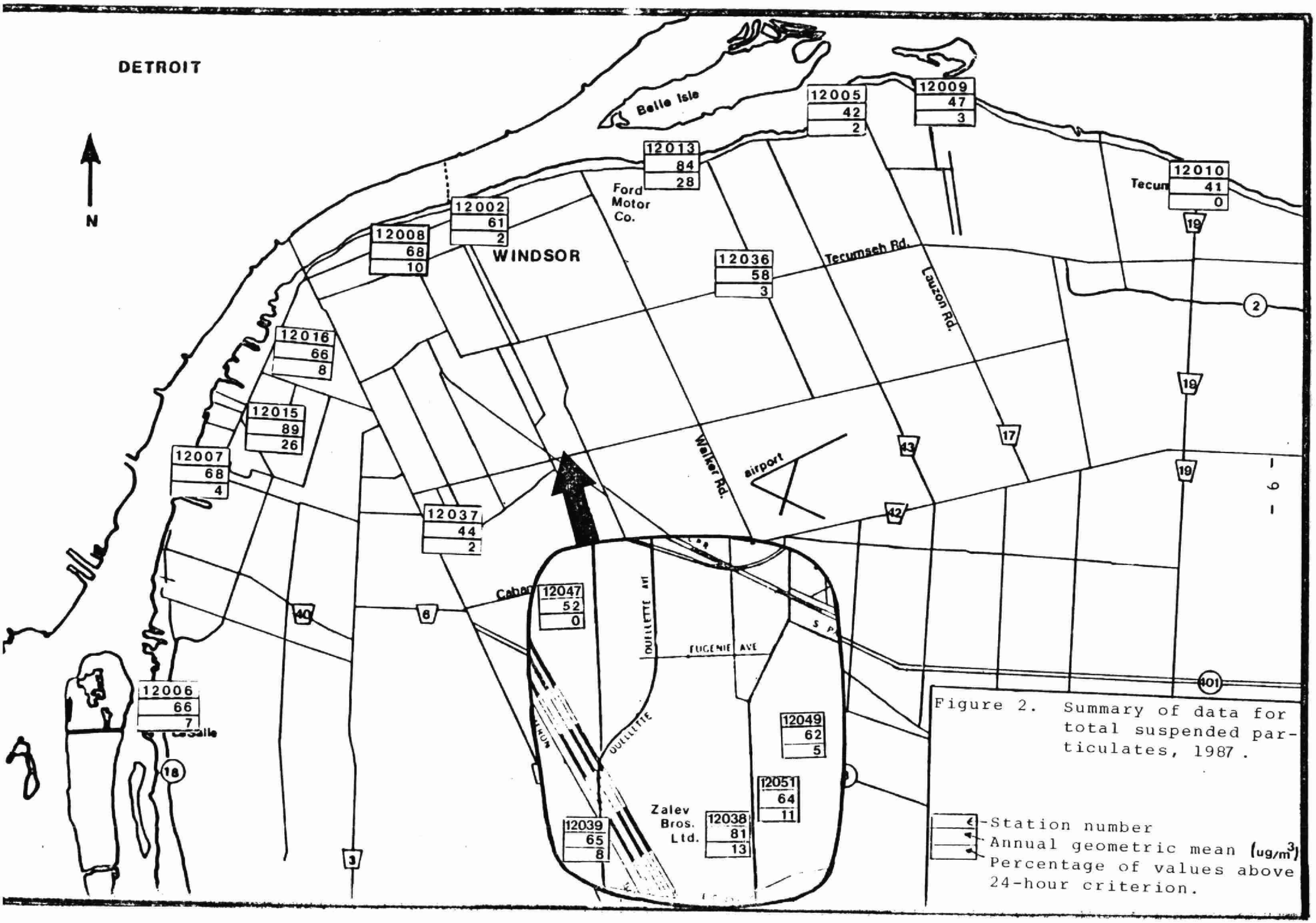

DETROIT
N
Belle Isle
12005
42
2
12009
47
3
12013
84
28
Ford
Motor
Co.
12002
61
2
12008
68
10
WINDSOR
12036
58
3
Tecumseh Rd.
Lauzon Rd.
12010
41
0
Tecum
12016
66
8
12015
89
26
12007
68
4
Walker Rd.
airport
12037
44
2
Cabana
12047
52
0
DUELLETTE AVE
EUGENIE AVE
12006
66
7
12049
62
5
12051
64
11
Zalev
Bros.
Ltd.
12039
65
8
12038
81
13
Figure 2. Summary of data for total suspended particulates, 1987.
Station number
Annual geometric mean (ug/m3)
Percentage of values above 24-hour criterion.

Figure 3. Trend in annual levels of total suspended particulates based on averaged data from eleven monitoring stations.

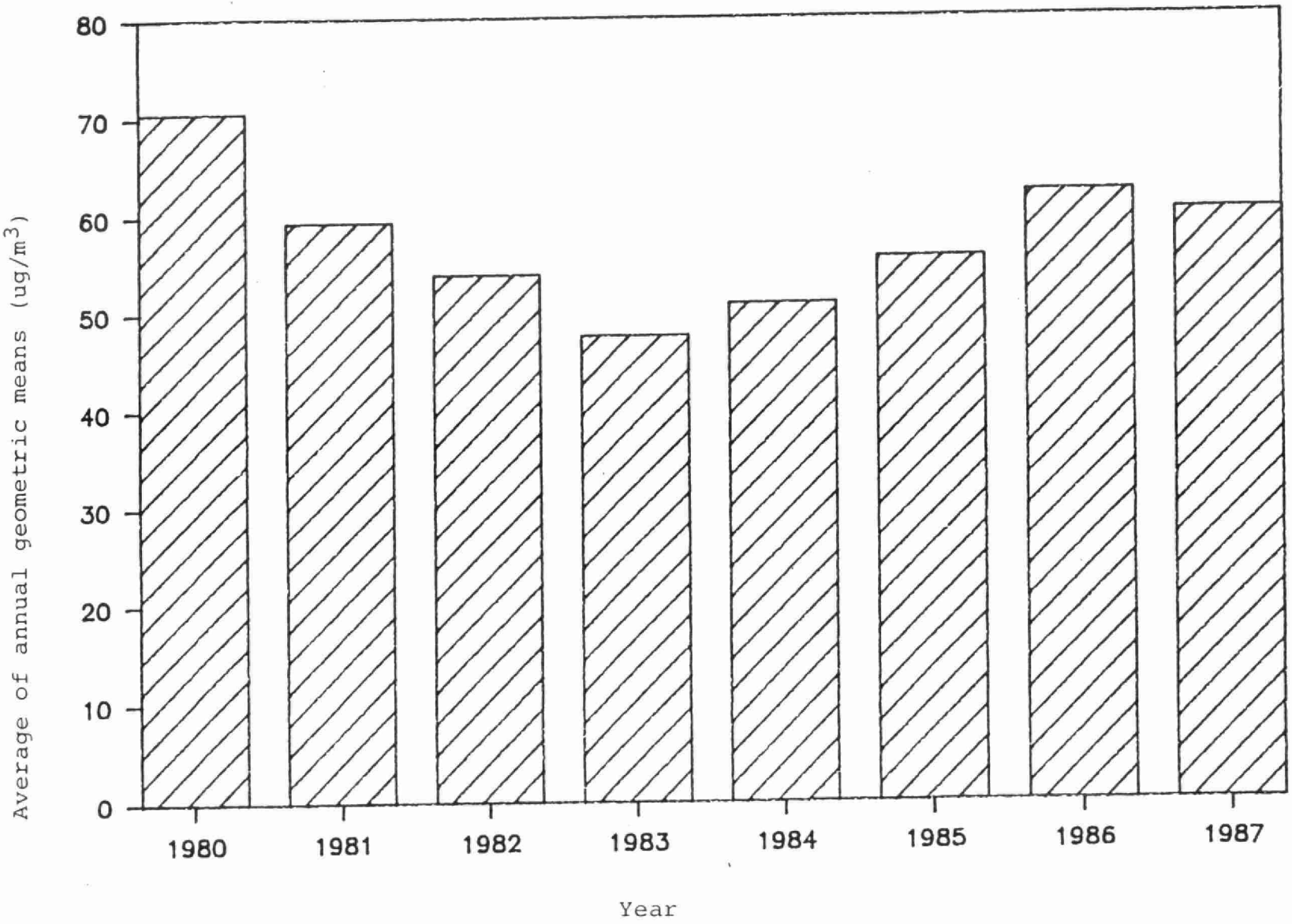
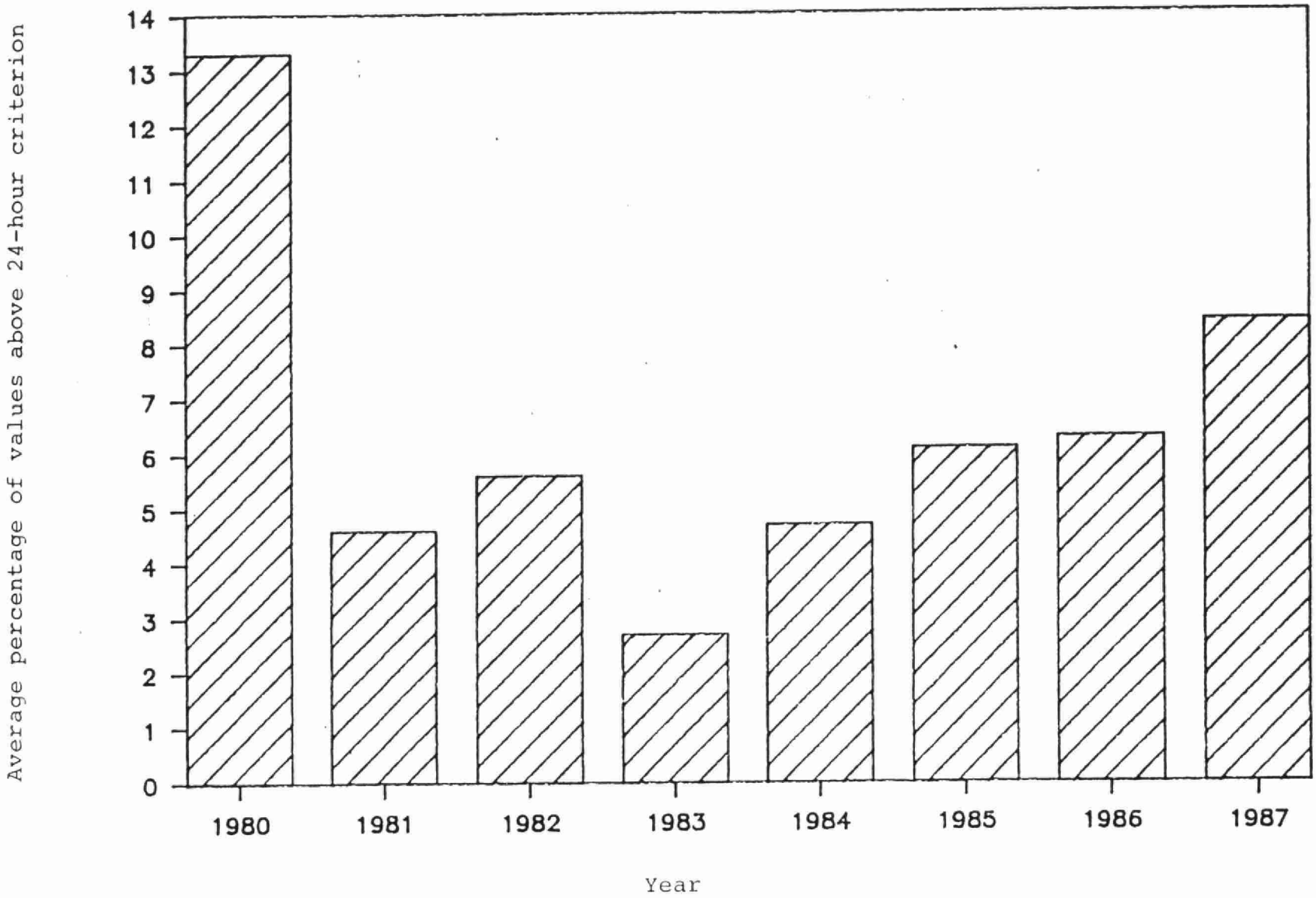


Figure 4. Trend in excursions above 24-hour criterion for total suspended particulates based on data from eleven monitoring stations.



In Windsor there are a number of areas where there are concerns about total suspended particulate levels. One of these areas is around the scrap metal operations of Zalev Brothers Limited. Since 1979 sampling has been conducted at station 12039 near Zalev Brothers Ltd. Early in 1985 four additional monitoring sites were established in this area. In March 1986 one of the new stations (station 12050) was terminated because of a new building being erected at the site. In May 1986 a new station (no. 12051) was started at a new site to replace the terminated one.

The 1987 suspended particulate data from stations near Zalev Brothers Limited reveal a greater impact from the scrap metal operations in 1987 than in 1986. Levels of particulates and iron and manganese which are indicative of scrap metal and foundry operations were higher in 1987.

Station 12038, which is located at the Ivy Rose Motel, is closest to the scrap metal operations and is subjected to an appreciable higher impact from the emissions than the other monitoring stations. The data for station 12047 at Dorwin Plaza and station 12049 on Alexandrine Street indicate very little and infrequent impact by emissions from the scrap metal operations. Stations 12039 at Windsor Teacher's College and 12051 on Capital Street are closer to the scrap metal operations than stations 12047 and 12049. A greater impact on particulate levels is evident at stations 12039 and 12051 compared to stations 12047 anfd 12049.

The impact at the Ivy Rose Motel is probably clearest by comparing the average iron concentration of 7.5 ug/m^3 to the level of 2.5 ug/m^3 measured at the Windsor Teacher's College. The 3 fold increase in iron level is attributable to emissions from the scrap metal operation. The average iron levels for 1987 are illustrated in Figure 5.

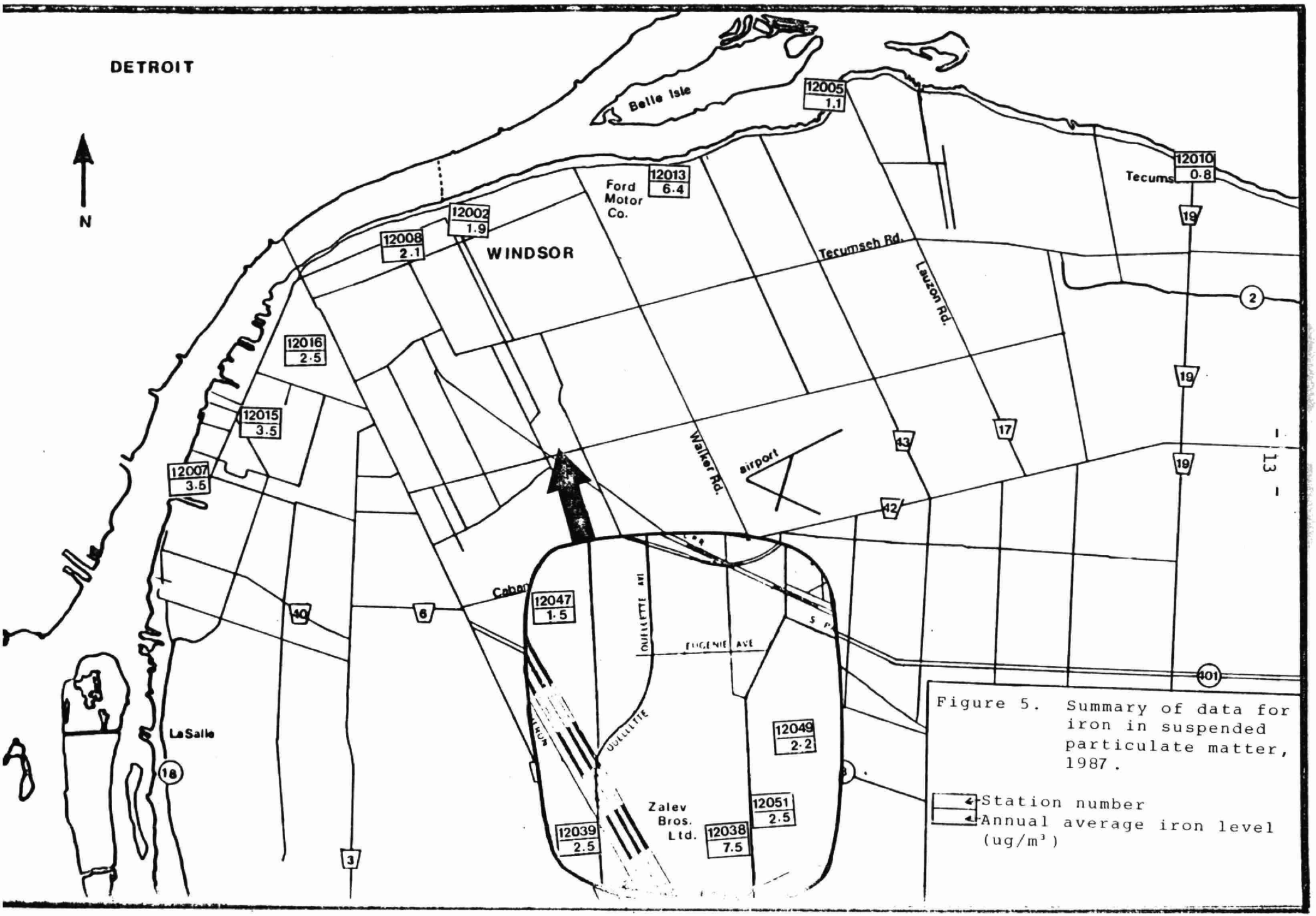


Figure 5. Summary of data for iron in suspended particulate matter, 1987.

In addition to the total suspended particulate samples collected in the vicinity of Zalev Brothers Ltd., soiling index measurements were conducted at stations 12038, 12039 and 12049. The soiling index samplers collect samples for a 1-hour duration compared to the 24-hour duration of the Hi-Vol sampler. The soiling index samplers collect suspended particulates that are representative of a smaller size of particulate matter than the Hi-Vol sampler. Also, sample collection appears to be strongly influenced by wind speed. A summary of the soiling index data appears in Table 2. The average soiling index values were highest at station 12038 and lowest at station 12049. The 24-hour criterion of 1.0 COH was exceeded most frequently at station 12039 and almost as frequent at station 12038. The excursions at station 12039 are attributable in part to emissions caused by traffic on the E.C. Row Expressway. The 24-hour criterion for desirable ambient air quality of 1.0 COH is based on impairment to visibility.

The soiling index samplers are proving to be of limited value in determining the impact of emissions of particulate from Zalev Brothers Ltd. on ambient air quality. This is believed to be because the soiling index sampler collects only very small-sized particles and the representativeness of the sample collection is adversely affected by wind speed.

Table 2. Summary of Soiling Index Data

Station Number	No. of 1-Hour values	Annual Average Soiling Index (1)	No. of Values Greater Than 24-Hour Criterion	% of Values Greater Than 24-Hour Criterion
12038	7543	0.51	6	1.9
12039	7810	0.49	7	2.2
12049	6774	0.43	1	0.4

(1) Soiling index is expressed as co-efficient of haze per 1000 feet of air. The annual criterion is 0.5 COH. The 24-hour criterion is 1.0 COH.

Another area of concern in Windsor is in the vicinity of the casting plant of Ford Motor Company of Canada Limited. Station 12013 is the closest monitoring station to the casting plant. Levels of total suspended particulates were unsatisfactory at this location in 1987 and have been for many years. The annual criterion of 60 ug/m^3 was exceeded by the 1987 value of 84 ug/m^3. The 24-hour criterion was exceeded by 28 per cent of the samples collected. Station 12013 experiences much higher levels of iron and manganese than other monitoring stations in the Windsor area with the exception of station 12038 located at the Ivy Rose Motel and impacted by the emissions from Zalev Brothers Ltd.

At station 12013 very high levels of total suspended particulates (values greater than 200 ug/m^3) were measured appreciably more frequently than at other stations. This was also true in 1986. On most days when total suspended particulate levels are high at station 12013 the winds are blowing from the foundry towards the monitoring station and iron levels are also elevated. For example on June 8 and 14 total suspended particulate levels were 249 and 232 ug/m^3 respectively and the corresponding iron levels were 27.7 and 30.8 ug/m^3.

The concern for air quality in the vicinity of the foundry is increased because of the trend towards higher levels of particulates in recent years despite improvements in certain emission controls.

Levels of total suspended particulates in west Windsor are also a concern. For the past four years the highest annual geometric mean for total suspended particulates in Windsor has been measured at station 12015 in west Windsor. In recent years stations 12007 and 12016 which are also located in west Windsor have had annual geometric mean values greater than the criterion for desirable ambient air quality.

Station 12015 is affected by emissions from the heavily industrialized area of downriver Detroit, road traffic and may be the local salt company. The impact of the downriver Detroit industry is reflected by iron and manganese levels being elevated above background. Iron and manganese are indicators of emissions from the steel industry as well as foundries. Elevated chloride levels indicate a possible impact from the local salt company. An evaluation of chloride levels at station 12007 and 12015 along with wind direction suggests that the salt processing plant and not the mining operation could be contributing to the increase in chloride levels. Further investigation is required to evaluate the impact of the salt processing plant.

Total particulate samples which were analyzed for specific components from 1981 through 1987 have the results summarized in Table A4 of Appendix 2. Criterion for desirable ambient air quality exist for cadmium, chromium, lead, nickel and vanadium (listed in Table A3). With the exception of iron, concentrations of the various metals have been traditionally low with no values above the criterion. Although criteria do not exist for some components reported these components can provide valuable information regarding the sources of the particulates.

SULPHUR OXIDES

Combustion of sulphur-containing fuels comprises the predominant source of man-made emissions of sulphur oxides. The primary emitters of sulphur oxides are power generating plants and industries utilizing fossil fuels to meet requirements for large amounts of energy.

During 1987 sulphur oxides were measured in Windsor as gaseous sulphur dioxide and as sulphate in suspended particulate matter. Data for sulphate in suspended particulates are presented in Table A4 supporting the section on Suspended Particulates. However, the sulphate values are appreciably higher than actual ambient levels because of sulphur dioxide forming artifact through reaction with the glass fibre filter. The Ministry is considering changing to a different filter-type to eliminate the artifact formation.

The criteria for desirable ambient air quality with respect to gaseous sulphur dioxide are 0.25 parts of sulphur dioxide per million parts of air (ppm) averaged for 1 hour, 0.10 ppm averaged for 24 hours (midnight to midnight) and 0.02 ppm as an annual average. The 1-hour and annual criteria were established for the protection of vegetation while the 24-hour criterion serves to protect human health.

These criteria for sulphur dioxide were not exceeded during 1987 at any of the six fixed locations in Windsor where the Ministry monitors sulphur dioxide. The monitoring locations are shown in Figure 1 as stations 12007, 12008, 12013, 12016, 12047 and 12048. A summary of the 1987 data is presented in Table 3.

Table 3 Summary of 1987 Sulphur Dioxide Data

Station Number	Annual Average (ppm)	Highest 1 Hr. Value (ppm)	Highest 24 Hr. Value (ppm)	Percentage of Values Greater Than	
				1 Hr. Criterion	24 Hr. Criterion
12007	0.007	0.13	0.03	0	0
12008	0.008	0.11	0.03	0	0
12013	0.006	0.13	0.02	0	0
12016	0.005	0.11	0.03	0	0
12047	0.007	0.18	0.03	0	0
12048	0.004	0.09	0.02	0	0

During the 1980's levels of sulphur dioxide in the Windsor area have been good with the criteria for desirable ambient air quality not being exceeded.

Figure 7 contains pollution roses showing the average concentration of sulphur dioxide associated with winds from different directions. These roses indicated higher average concentrations when winds are blowing from Michigan towards the monitoring stations in Windsor. However, the repeated conformity to criteria for desirable ambient air quality indicate that Michigan sources of sulphur dioxide are not adversely affecting air quality in Windsor.

AIR POLLUTION INDEX

The Air Pollution Index (API) is a system designed to control or prevent an air pollution episode. Meteorological forecasting and readings of sulphur dioxide and suspended particulates are utilized to predict the potential for the persistence of deteriorating air quality conditions that are numerically reported as the API.

Data for suspended particulates are provided by the measurement of soiling index and a correlation between concentrations of suspended particulates and soiling index. Hourly values of soiling index and gaseous sulphur dioxide are used to compute 24-hour running averages which are inserted into the following equation:

$$API = 0.78\ (18.26\ COH + 156.7\ SO_2)^{1.06}$$

where: COH is the 24-hour average for soiling index expressed in co-efficient of haze units.

SO_2 is the 24-hour average concentration of sulphur dioxide expressed in parts per million.

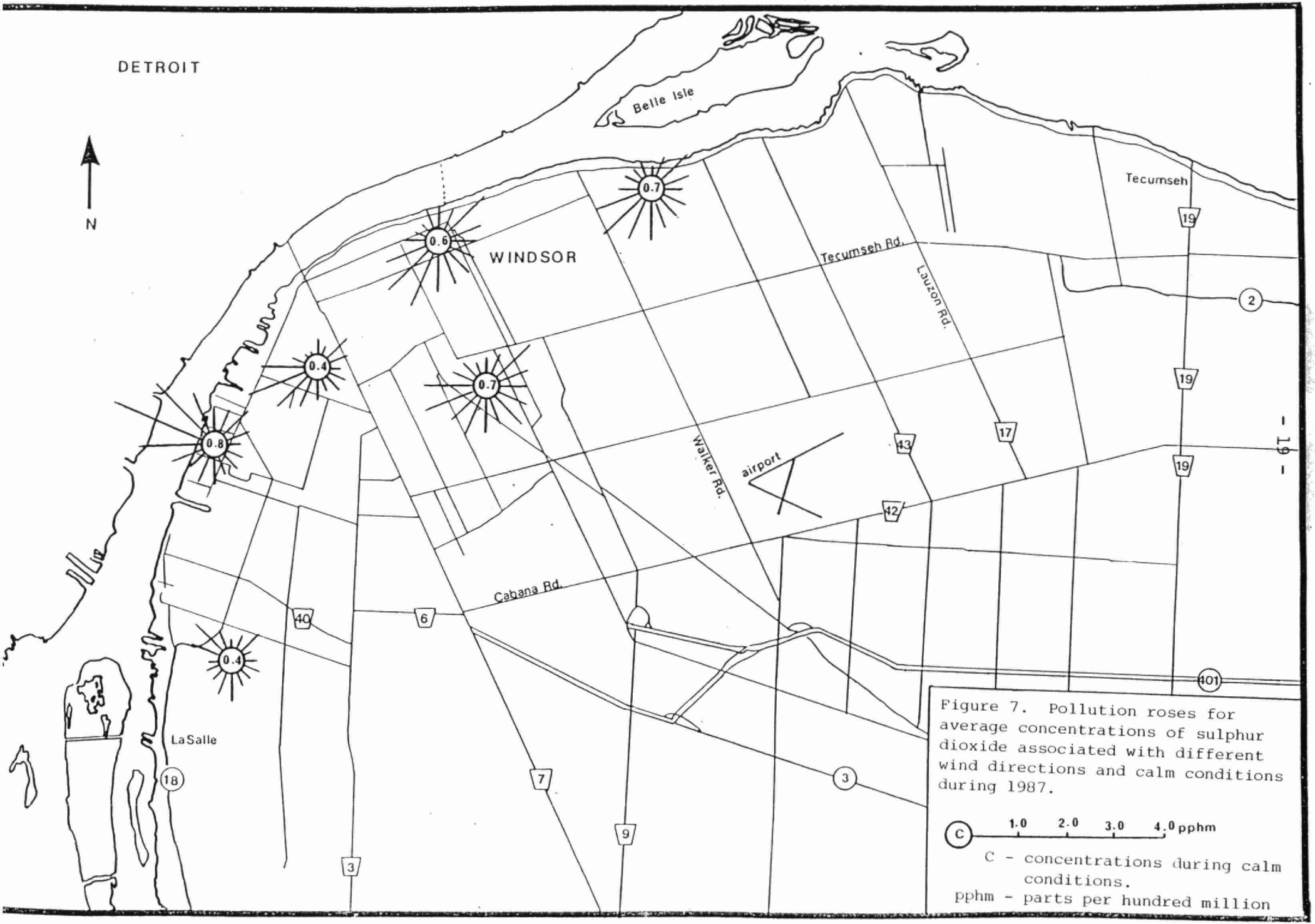


Figure 7. Pollution roses for average concentrations of sulphur dioxide associated with different wind directions and calm conditions during 1987.

C 1.0 2.0 3.0 4.0 pphm

C - concentrations during calm conditions.
pphm - parts per hundred million

API values up to 32 are considered acceptable. Values from 32 to 49 are at the Advisory Level and if adverse weather conditions are likely to persist, major emitters are advised to prepare to curtail operations. At an API of 50, major emitters may be ordered to curtail operations. At 75, further cutbacks can be required. If the API reaches 100 all industries and other pollution generating activities not essential to public health and safety can be ordered to cease operation.

Levels of soiling index and sulphur dioxide utilized for the computation of the API are obtained at station 12008 in downtown Windsor, and at station 12016 in west Windsor. During 1987 all API values were below the Advisory Level of 32. In 1988 the Air Pollution Index was incorporated into the broader Air Quality Index.

TOTAL REDUCED SULPHUR

Gaseous total reduced sulphur compounds often exhibit malodours at very low concentrations. Hydrogen sulphide is a reduced sulphur compound commonly referred to as rotten egg gas. Mercaptans are also reduced sulphur compounds that exhibit characteristics similar to hydrogen sulphide, including being malodorous at extremely low concentrations.

There are many sources of reduced sulphur compounds including natural decomposition of organic material. In west Windsor there are occasional malodours which may be caused by reduced sulphur compounds. Probable sources of these odours are the operations of the steel industry in Wayne County, Michigan and sewage composting in West Windsor. There has also been suspicion that some of the malodours experienced in the vicinity of the casting plant of Ford Motor Company of Canada, Limited may be caused by reduced sulphur compounds.

The Ministry of the Environment has a desirable ambient air quality criterion for mercaptans of 10 parts per billion (ppb) during a 1-hour period. There is also a criterion for hydrogen sulphide which is 20 ppb during a 1-hour period. These criteria were established on the basis of odour. Unfortunately the instrument used by the Ministry to measure total reduced sulphur compounds does not differentiate between hydrogen sulphide and mercaptans. The instrument reports the combined levels of hydrogen sulphide and mercaptans as total reduced sulphur, expressed as hydrogen sulphide. In consideration of the combined levels measured by the instrument, the levels are compared with the less restrictive criterion for hydrogen sulphide.

During 1987 monitoring for total reduced sulphur was conducted at station 12007 in west Windsor and station 12013 near the casting plant of Ford Motor Company of Canada, Limited. No excursions have been measured at station 12013 since monitoring began in 1984. However, at station 12007 there were 162 measured excursions above the 1-hour hydrogen sulphide criterion. This represents 2.2 per cent of the measurements made in 1987 at this station. The 1986 data for station 12007 also revealed unsatisfactory levels of total reduced sulphur compounds. A summary of data for total reduced sulphur compounds is presented in Appendix 3, Table A5.

The elevated levels of total reduced sulphur compounds at station 12007 are associated with winds blowing from the heavily industrialized area of Zug Island in Wayne County, Michigan. Figure 8 contains pollution roses that show the average concentration of total reduced sulphur compounds associated with various wind directions as measured at the 46-metre level at station 12007. The rose for station 12007 indicates much higher levels of total reduced sulphur compounds occur when the winds are blowing from Zug Island towards the monitoring station. Ministry staff servicing the equipment at station 12007 frequently detect rotten-egg type odours when the winds are blowing from Zug Island.

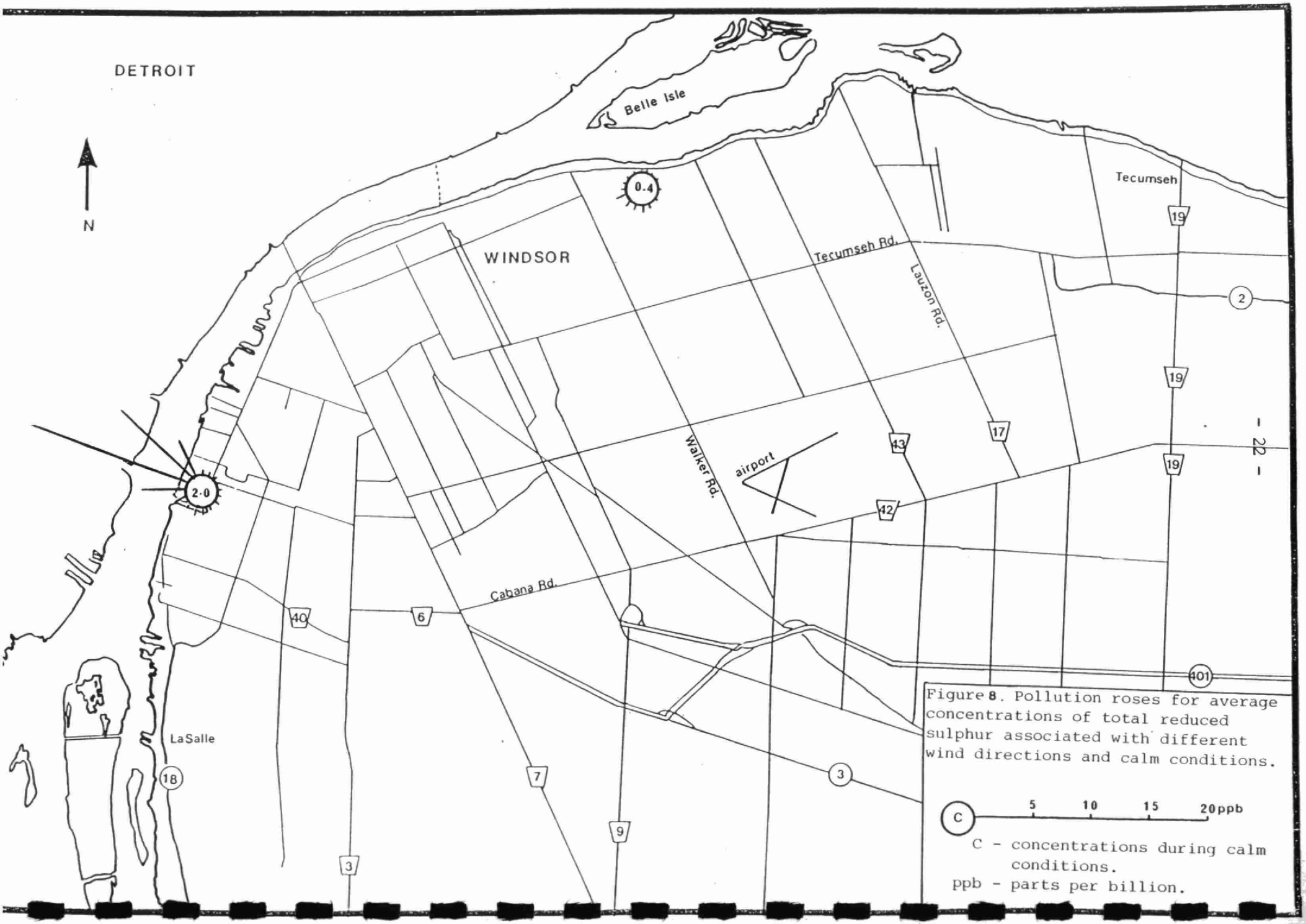


Figure 8. Pollution roses for average concentrations of total reduced sulphur associated with different wind directions and calm conditions.

The ambient air monitoring does not indicate an impact at station 12007 when winds are blowing from the west Windsor composting operations. However, Ministry staff detected malodours in close vicinity of the composting operation.

The rose for station 12013 shows that average concentrations are low for all wind directions although they are higher when the winds are blowing from the west-southwest and southwest. These winds would blow emissions from the casting plant of Ford Motor Company and emissions from the Zug Island area towards the monitoring station. Consequently the increased levels cannot be attributed solely to either the casting plant or Zug Island but since the levels are low and the desirable ambient air criterion is met, this does not create any difficulty.

CARBON MONOXIDE

Combustion processes account for man's major emissions of carbon monoxide. Emissions from motor vehicles are especially significant because they are near ground level and are concentrated in urban areas where the public may be exposed for long periods. Major industries and power generating plants normally provide adequate dispersion for their emissions to prevent unsatisfactory levels of carbon monoxide in ambient air.

The criteria for carbon monoxide are 30 ppm averaged for 1 hour and 13 ppm averaged for any consecutive 8 hours. These criteria were established for the protection of human health and have not been exceeded in the past 10 years, based on monitoring at station 12008. Since this station is located in the downtown area of Windsor where the highest levels of carbon monoxide are anticipated, there is a high probability that levels are acceptable throughout the Windsor area.

A summary of data for carbon monoxide, obtained since 1980, is presented in Appendix 3, Table A5.

OXIDES OF NITROGEN

Like many other pollutants, oxides of nitrogen are emitted into the atmosphere by man through combustion processes. Nitric oxide and nitrogen dioxide are of primary interest.

Criteria for desirable ambient air quality exist for nitrogen dioxide, but not for nitric oxide or total oxides of nitrogen. The criteria for nitrogen dioxide, which are based on the protection of human health and offensive odours, are 0.20 ppm averaged for 1 hour and 0.10 ppm averaged for 24 hours (midnight to midnight).

Oxides of nitrogen are measured at station 12008, located in downtown Windsor. The nitrogen dioxide criteria for desirable ambient air quality have not been exceeded in the 1980's. Since emissions from motor vehicles are concentrated in the downtown area, levels of oxides of nitrogen would probably be higher at station 12008 than in other areas of Windsor. A summary of the data for oxides of nitrogen is presented in Table A5, Appendix 3.

Although levels of nitrogen dioxide have been very favourable when compared to the criteria, there is concern about oxides of nitrogen because of acidic precipitation and their role in the formation of unsatisfactory levels of photochemical oxidants. Consequently, more stringent controls for oxides of nitrogen are under consideration. New emission standards for 1988 model cars is one example of more stringent controls being implemented.

HYDROCARBONS

The principal man-made sources of hydrocarbons are emissions from landfill sites and motor vehicles. The landfill emissions are primarily methane from the natural decomposition of the garbage. Other significant man-made sources are incomplete combustion of fuels by industries and power generating plants and evaporation losses during manufacture, use, storage and transportation of materials containing volatile hydrocarbons. In the Windsor area, hydrocarbon emissions from distilleries and distillery warehouses account for a large proportion of emissions from stationary sources. Also emissions from motor vehicle painting are significant in the Windsor area. Natural phenomena produce many hydrocarbons of which methane is the most abundant.

Owing to the wide range of effects associated with different hydrocarbons at various concentrations, no criteria for desirable ambient air quality have been established for total hydrocarbons. Instead, control is achieved by setting criteria for desirable levels of specific hydrocarbons in ambient air and/or establishing standards which control the impact of emissions of specific hydrocarbons.

Although there are no criteria for total hydrocarbons, monitoring for them provides information on trends in levels of hydrocarbons. Increasing levels of hydrocarbons could be significant should they be attributable to detrimental compounds. Furthermore, the non-methane or "reactive" hydrocarbons may partake in photochemical reactions which produce excessive levels of oxidants.

Total hydrocarbons, methane and non-methane hydrocarbons are monitored continuously at station 12008 in downtown Windsor using flame ionization detection. In July, 1987 the Ministry of the Environment and Environment Canada began a co-operative ambient air monitoring program for specific hydrocarbons as well a

specific chlorinated organics, polyaromatic hydrocarbons and inhalable particulates. Station 12008 is the monitoring site for this co-operative monitoring program and the analytical results are reported in the report "Detroit Incinerator Monitoring Program, Data Report #1, Windsor Air Sampling Site, July 1987 - November 1987", Environment Canada, Ottawa, Ontario.

The Ministry also conducts special monitoring surveys for specific hydrocarbons using mobile monitoring vans. These surveys are usually very complicated and difficult. Often they must be repeated several times to properly identify and quantify specific hydrocarbons.

Levels of total hydrocarbons and reactive hydrocarbons have been similar in recent years with no trend of changing levels. A summary of annual average concentrations appears in Table A5, Appendix 3.

OXIDANTS

A major portion of the oxidants in ambient air are a result of photochemical reactions and inter-reactions involving oxides of nitrogen and reactive hydrocarbons. The reactions are promoted by certain meteorological conditions such as warm temperatures and intense sunshine. Consequently, higher levels of oxidants are experienced in the spring and summer months.

Ozone normally accounts for 80 to 90 percent of the photochemical oxidants in ambient air. The monitoring technology for ozone is more accurate and efficient than that for total oxidants. For these reasons, most regulatory agencies, including this Ministry, monitor for ozone rather than total oxidants.

Ozone is also present in the stratosphere where it plays the critical role of absorbing ultraviolet radiation that in excessive amounts may be biologically harmful. Occasionally ozone from the stratosphere may be transported downwards to cause elevated concentrations at the earth's surface. Ozone is naturally produced in minor amounts by lightning.

Long-range transport of ozone and its precursor chemicals (oxides of nitrogen and hydrocarbons) can account for a very significant portion of local levels of ozone. Incidents of long-range transport from distances greater than 200 kilometres have been reported in the literature. Consequently, successful control of oxidants will depend on control strategies implemented in the United States as well as in Ontario.

The Environmental Protection Agency (EPA) in the United States has established a primary standard for ozone of 0.12 ppm averaged for 1 hour. Individual states were required to develop control strategies to bring ozone levels into compliance by the end of 1987. However, the 1987 date has not been met by some states and extensions have been granted. The EPA primary standard was established for the protection of human health.

The Ontario criterion for desirable ambient air quality is 0.08 ppm averaged for 1 hour. This criterion was established for the protection of vegetation, property and human health. Some effects detrimental to health that are associated with oxidants are eye irritation and a decrease in performance during physical activities. Oxidant damage to crops in Ontario is estimated at millions of dollars annually. Ontario has established a special section in its Long-Range Transport of Air Pollutants program to study the oxidant situation and to develop a suitable control strategy. More stringent standards are now required for new motor vehicles in Canada which should significantly reduce oxidant precursor emissions.

Ozone is monitored in downtown Windsor at station 12008. During 1987 there were 69 hourly values reported in excess of the 1-hour criterion of 80 ppb. The excursions all occurred during the period of April through September. With the photochemical formation of ozone being dependent on meteorological conditions, there may be large fluctuations from year to year in the frequency of excursions above the criterion. A summary of ozone data appears in Table A5, Appendix 3.

A pollution rose for 1987 data is presented in Figure 9 to show the frequency of the total number of excursions above the criterion associated with different wind directions. The greatest frequency of excursions is associated with southerly winds. These winds are apt to be associated with the backs of high pressure systems or the area south of low pressure fronts which have weather favourable for photochemical reactions (clear sunny skies and warm temperatures) and which promote long-range transport of oxidants and their precursor chemicals.

FLUORIDES

Sources of fluorides in the Windsor area are the steel industry located in the downriver area of Wayne County, Michigan, power generating plants where coal burned contains trace amounts of fluorides, fluorspar unloading operations at docks in west Windsor and subsequent trucking of fluorspar to other locations.

Fluoridation rate is a measurement designed to indicate the relative amounts of gaseous fluoride present over an extended period of time. A lime-impregnated filter is exposed to ambient air for thirty days and then analyzed for fluoride content. This monitoring technique measures primarily gaseous fluoride but some fluoride in particulate form may be collected on the filter.

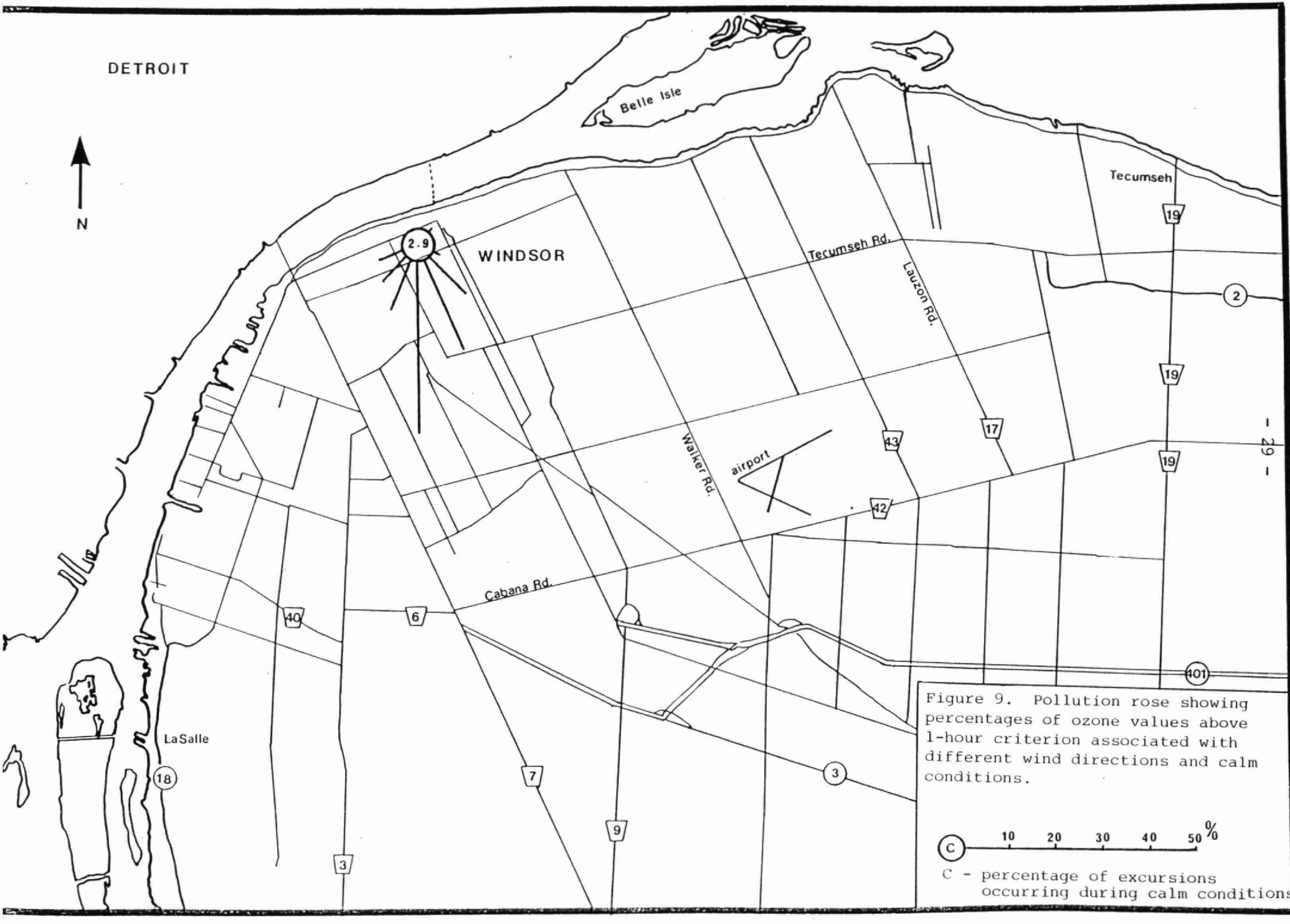


Figure 9. Pollution rose showing percentages of ozone values above 1-hour criterion associated with different wind directions and calm conditions.

C 10 20 30 40 50 %

C - percentage of excursions occurring during calm conditions

The criteria for desirable ambient air quality established for fluoridation rate are based on the protection of vegetation. Consequently, a criterion of 40 micrograms of fluoride per 100 square centimetres of filter per 30 days (ug F/100 cm^2/30 days) has been established for the growing season from April 15 to October 15 while a criterion of 80 ug F/100 cm^2/30 days applies for the period of October 16 to April 14. Since the months of April and October are common to both criteria and fluoridation rate is measured on a monthly basis, excursions during these months are determined by comparing the fluoridation rate to the average of the two criteria (60 ug F/100 cm^2/30 days).

During 1987 there were seven sites where fluoridation rates were monitored, 4 in west Windsor and 3 in the downtown area. The criterion for the non-growing season was not exceeded at the seven stations in 1987. However, the growing season criterion was exceeded at all stations. At the stations in west Windsor the growing season criterion was exceeded on two to four occasions per station while at the downtown stations the excursions were once per station. Figure 10 summarizes the 1987 fluoridation rates for the various monitoring sites. The 1987 data appear in Table 4.

Fluoridation rate is not considered a sensitive indicator of temporal trends of fluoride levels. However, the appreciable increase in the average fluoridation rates values and the number of excursions above the growing criterion during 1987 causes concern. The increase is illustrated in Figures 11 and 12 which for six monitoring stations indicate the trend in the annual average of fluoridation rates and the frequencies of excursions above the criteria for desirable ambient air quality since 1980.

Although the 1987 fluoridation rates are high compared to the levels experienced in other years of the 1980's, they are lower than the levels generally experienced in the 1970's.

Past investigations by Ministry staff have revealed elevated levels of fluorides in vegetation. Fluorspar handling at the Morten Terminal has been identified as a source causing a localized impact on fluoride levels in grass. With the increase in fluoridation rate levels in 1987 it is important that additional vegetation and fluoridation rate studies be conducted and that sources of fluoride emissions be reviewed.

Table 4 Levels of fluoridation rate during 1987

Station Number	Fluoridation rate (ugF/100 cm^2/30 days) Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Average	Percentage of values above criteria
12007	65	41	29	28	46	76	34	54	27	35	46	37	43	25
12008	76	20	14	21	32	34	36	47	8	29	42	22	32	8
12015	69	33	39	24	126	79	68	97	31	40	47	36	57	33
12016	53	26	27	22	68	40	43	73	27	34	28	43	40	25
12022	26	20	18	15	62	32	28	31	11	29	15	19	26	8
12027	17	14	13	12	43	31	21	38	13	19	14	30	22	8
12040	31	15	25	18	28	55	22	54	11	18	64	17	31	17

Note: Underlined values exceed growing season criterion for desirable ambient air quality.

The growing season criterion is 40 ugF/100 cm^2/30 days. The non-growing season criterion is 80 ugF/100 cm^2/30 days.

Figure 11. Trend in annual levels of fluoridation rate based on averaged data for six monitoring stations.

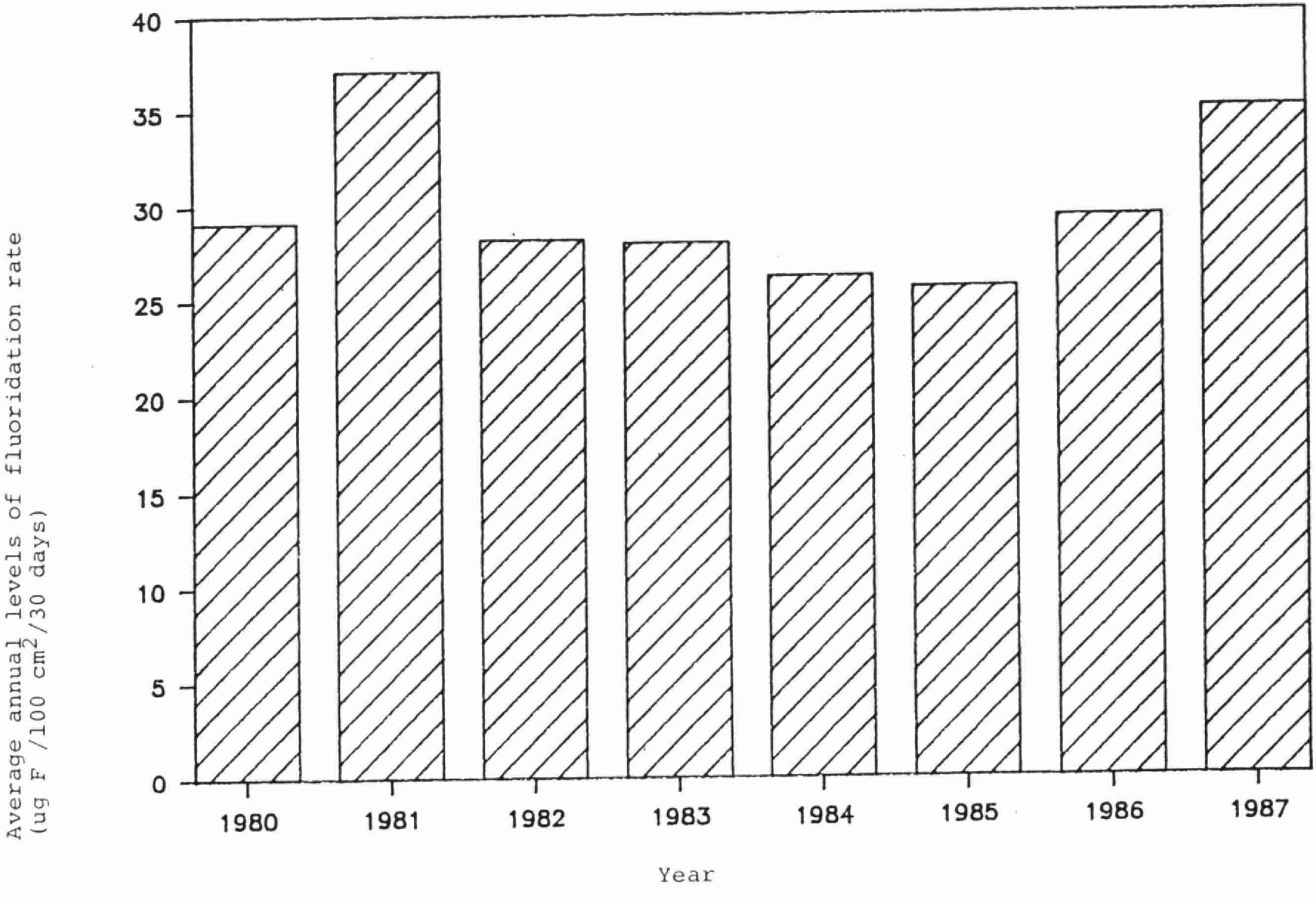
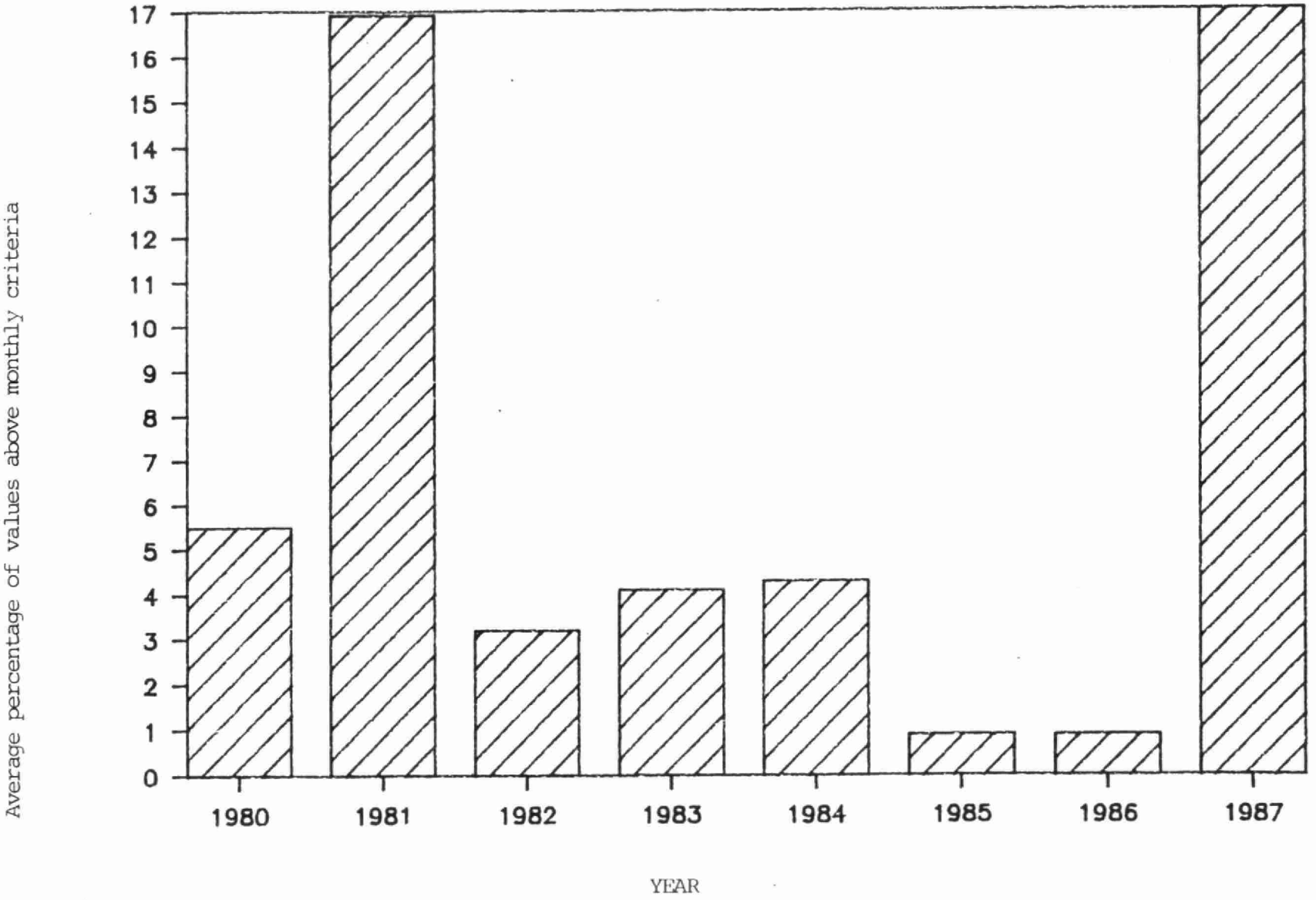


Figure 12. Trend in excursions above monthly criteria for fluoridation rate based on averaged data from six monitoring stations.



APPENDIX 1

DESCRIPTION OF MONITORING NETWORK

Table A1. Locations of air monitoring stations

Station number	Location	Universal transverse mercator projection co-ordinates	Elevation above sea level (metres)	Air intake height (metres)
12002	444 Windsor Avenue, City Hall	03323 - 46867	183	17
12005	7730 Riverside Drive East	03395 - 46890	177	10
12006	Beach Lane/Hwy. 18 (LaSalle)	03264 - 46778	176	4
12007	Wright St./Water St.	03271 - 46823	177	4, 10 & 46
12008	467 University Avenue	03316 - 46867	183	12
12009	Tecumseh Water Works	03413 - 46888	180	2
12010	Tecumseh Sewage Pumping Station	03460 - 46875	181	1
12013	3665 Wyandotte Street East	03358 - 46874	185	7 & 10
12015	Highway No. 18/Prospect	03283 - 46833	175	6
12016	College/South Street	03290 - 46841	175	4
12022	Hickory/Richmond Street	03352 - 46870	183	5
12027	1526 Parent Street	03340 - 46852	183	5
12036	1794 Westcott Street at Milloy Street	03367 - 46858	186	5
12037	3225 California Street (St. Hubert's School)	03327 - 46816	183	4
12038	2885 Howard Ave.	03342 - 46826	195	1
12039	Dougall St./E. C. Row W	03337 - 46821	195	5
12040	225 Willow Drive (La Salle)	03261 - 46773	175	5
12047	Dorwin Plaza, Dougall Ave.	03327 - 46834	187	3
12048	Malden Rd./Laurier Ave.	03299 - 46766	178	3
12049	643 Alexandrine St.	03343 - 46832	190	1
12051	604 Capital St.	03344 - 46828	195	1

Table A2. Parameters (1) monitored in the ambient air in Windsor during 1987

Station Number	Air Pollution Index	Carbon Monoxide	Fluoridation Rate	Hydrocarbons	Nitric Oxide	Nitrogen Dioxide	Nitrogen Oxides	Ozone	Soiling Index (1-hr COH)	Sulphur Dioxide	Suspended Particulates	Total Reduced Sulphur
12002											X	
12005											X	
12006											X	
12007			X							X	X	X
12008	X	X	X	X	X	X	X	X	X	X	X	
12009											X	
12010											X	
12013										X	X	X
12015			X								X	
12016	X		X						X	X	X	
12022			X									
12027			X									
12036											X	
12037											X	
12038									X		X	
12039									X		X	
12040			X									
12047										X	X	
12048										X		
12049									X		X	
12051											X	

(1) Does not include parameters monitored jointly by Environment Canada and Ontario Ministry of the Environment as part of the Detroit incinerators program.

Table A3. Desirable ambient air quality criteria established by the Ontario Ministry of the Environment

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Carbon monoxide	30 ppm averaged for 1 hour	Protection of human health
	13 ppm averaged for 8 hours	Protection of human health
Fluoridation rate	40 ug of fluorides/100 cm^2 of limed filter paper in 30 days during April 15 to October 15	Protection of vegetation
	80 ug of fluorides/100 cm^2 of limed filter paper in 30 days during October 16 to April 14	Protection of vegetation (less restrictive criterion during the non-growing season)
Hydrocarbons (total)	None	Effects of hydrocarbons vary widely depending on their chemical-physical nature
Hydrogen Sulphide	0.02 ppm averaged for 1 hour	Protection against offensive odours
Mercaptans	0.01 ppm averaged for 1 hour	Protection against offensive odours
Nitric oxide	None	Reacts with oxygen to produced NO_2
Nitrogen dioxide	0.20 ppm averaged for 1 hour	Protection of human health and protection against odours
	0.10 ppm averaged for 24 hours	Protection of human health and protection against odours
Oxides of nitrogen	None	

Table A3. continued

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Ozone	0.08 ppm averaged for 1 hour	Protection of vegetation, property and human health
Sulphur dioxide	0.25 ppm averaged for 1 hour	Protection of vegetation
	0.10 ppm averaged 1 day (24 hours)	Protection of human health
	0.02 ppm averaged for 1 year	Protection of vegetation
Suspended particulates	120 ug/m^3 averaged for 24 hours	Based on impairment of visibility and health effects
	60 ug/m^3 (geometric mean) during 1 year	Based on public awareness of visible pollution
Cadmium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of human health
Chromium in Suspended particulates	1.5 ug/m^3 averaged for 24 hours	Based on protection of human health
Lead in suspended particulates	5.0 ug/m^3 averaged for 24 hours	Based on protection of human health
	2.0 ug/m^3 as a geometric mean over a 30 day period	Based on protection of human health
Nickel in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of vegetation
Vanadium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of human health

APPENDIX 2

PARTICULATES

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3)

Station and Year	Cadmium			Chromium			Lead			Nickel			Vanadium		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12002															
1981	55	0.003	0.024	55	0.006	0.027	58	0.3	2.0	55	0.011	0.070	12	0.01	0.02
1982	51	0.003	0.014	51	0.007	0.090	54	0.3	1.0	51	0.007	0.027	55	0.01	0.02
1983	33	0.002	0.009	33	0.004	0.016	49	0.3	0.9	33	0.004	0.020	33	0.00	0.01
1984	34	0.002	0.012	34	0.004	0.009	57	0.1	0.6	34	0.003	0.008	34	0.01	0.02
1985	57	0.003	0.015	57	0.012	0.066	57	0.2	0.6	57	0.007	0.031	57	0.01	0.02
1986	55	0.002	0.012	55	0.010	0.045	50	0.1	0.4	55	0.007	0.150	55	0.01	0.04
1987	56	0.004	0.027	55	0.009	0.021	56	0.1	0.6	56	0.008	0.090	56	0.01	0.04
12005															
1981	59	0.003	0.035	59	0.004	0.030	59	0.3	2.6	58	0.008	0.085	50	0.01	0.03
1982	54	0.005	0.022	53	0.006	0.043	54	0.2	1.1	54	0.011	0.085	54	0.00	0.02
1983	52	0.002	0.010	48	0.002	0.011	51	0.2	0.6	52	0.004	0.017	50	0.00	0.01
1984	53	0.001	0.005	53	0.004	0.034	53	0.2	0.7	49	0.004	0.036	53	0.00	0.02
1985	59	0.002	0.005	59	0.009	0.016	59	0.1	0.3	59	0.010	0.298	59	0.01	0.03
1986	52	0.001	0.009	52	0.006	0.020	52	0.1	0.5	52	0.003	0.023	52	0.01	0.04
1987	60	0.001	0.007	60	0.007	0.011	60	0.1	0.2	60	0.006	0.080	60	0.01	0.02
12007															
1987							52	0.1	0.3						
12008															
1981	307	0.003	0.042	307	0.005	0.043	316	0.4	2.0	296	0.008	0.041	307	0.01	0.03
1982	318	0.003	0.027	317	0.005	0.024	313	0.3	1.3	318	0.007	0.071	319	0.01	0.03
1983	328	0.002	0.025	328	0.004	0.015	328	0.3	0.9	306	0.005	0.084	328	0.01	0.02
1984	344	0.003	0.031	343	0.005	0.117	345	0.3	1.1	343	0.007	0.234	343	0.01	0.14
1985	325	0.004	0.025	325	0.010	0.032	325	0.2	0.7	325	0.009	0.118	325	0.01	0.03
1986	313	0.003	0.023	313	0.009	0.042	313	0.2	1.8	313	0.004	0.150	313	0.01	0.07
1987	304	0.004	0.042	304	0.011	0.060	304	0.1	0.6	304	0.010	0.120	304	0.01	0.07
12009															
1986							56	0.1	0.6						
1987							59	0.1	0.3						

Note: 24-hr. criterion for cadmium, nickel and vanadium is 2.0 ug/m^3; 24-hr. criterion for lead is 5 ug/m^3 and for chromium 1.5 ug/m^3.

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Cadmium # of Samples	Cadmium Avg.	Cadmium Max.	Chromium # of Samples	Chromium Avg.	Chromium Max.	Lead # of Samples	Lead Avg.	Lead Max.	Nickel # of Samples	Nickel Avg.	Nickel Max.	Vanadium # of Samples	Vanadium Avg.	Vanadium Max.
12010															
1981	55	0.002	0.012	55	0.004	0.031	55	0.2	0.6	55	0.004	0.018	55	0.00	0.02
1982	57	0.002	0.005	56	0.002	0.009	55	0.2	0.8	57	0.006	0.018	57	0.00	0.05
1983	33	0.001	0.004	33	0.002	0.009	33	0.2	0.5	33	0.003	0.014	33	0.01	0.02
1984	32	0.001	0.004	32	0.004	0.024	32	0.2	0.7	27	0.007	0.105	32	0.00	0.03
1985	58	0.002	0.006	58	0.010	0.026	58	0.1	0.5	58	0.006	0.086	58	0.01	0.02
1986	54	0.002	0.011	54	0.008	0.049	54	0.1	0.6	54	0.005	0.037	54	0.01	0.03
1987	52	0.001	0.004	52	0.007	0.019	52	0.0	0.2	52	0.006	0.030	52	0.01	0.04
12013															
1981	53	0.002	0.011	54	0.008	0.029	53	0.3	1.2	53	0.004	0.017	53	0.01	0.02
1982	56	0.003	0.014	56	0.016	0.089	54	0.3	1.3	56	0.009	0.029	56	0.01	0.04
1983	56	0.002	0.011	56	0.009	0.044	56	0.2	0.7	56	0.006	0.024	56	0.00	0.02
1984	58	0.002	0.008	58	0.008	0.056	58	0.2	0.6	53	0.007	0.031	58	0.00	0.02
1985	57	0.003	0.012	57	0.012	0.029	57	0.2	0.5	57	0.007	0.024	57	0.01	0.02
1986	60	0.002	0.013	60	0.016	0.060	60	0.2	0.5	60	0.008	0.045	60	0.01	0.03
1987	58	0.003	0.015	58	0.032	0.240	57	0.1	0.3	58	0.012	0.040	58	0.01	0.03
12015															
1981	58	0.004	0.022	57	0.009	0.037	57	0.3	1.4	57	0.008	0.047	51	0.01	0.02
1982	53	0.005	0.074	53	0.008	0.059	52	0.2	0.8	53	0.010	0.102	53	0.01	0.13
1983	57	0.002	0.009	57	0.004	0.020	57	0.2	1.0	57	0.004	0.020	57	0.01	0.07
1984	47	0.003	0.027	47	0.006	0.019	47	0.1	1.0	47	0.005	0.023	47	0.00	0.02
1985	58	0.007	0.041	58	0.011	0.031	58	0.2	0.4	58	0.008	0.055	58	0.01	0.02
1986	53	0.003	0.013	53	0.012	0.047	53	0.1	0.3	53	0.006	0.019	53	0.01	0.02
1987	54	0.003	0.020	53	0.015	0.040	53	0.1	0.3	53	0.008	0.020	53	0.01	0.03
12038															
1986	56	0.002	0.017	56	0.012	0.045	56	0.2	0.7	56	0.005	0.208	56	0.00	0.02
1987	54	0.002	0.010	54	0.012	0.070	55	0.2	0.8	54	0.009	0.070	54	0.01	0.02

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Cadmium			Chromium			Lead			Nickel			Vanadium		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12039															
1986	54	0.002	0.023	54	0.010	0.039	56	0.3	1.0	54	0.002	0.022	56	0.01	0.05
1987	60	0.002	0.010	60	0.008	0.024	60	0.2	1.0	60	0.006	0.010	60	0.01	0.03
12047															
1986	52	0.002	0.017	52	0.005	0.019	52	0.1	0.3	52	0.005	0.130	52	0.01	0.02
1987	50	0.002	0.004	50	0.006	0.020	50	0.1	0.3	50	0.006	0.010	50	0.01	0.02
12049															
1986	53	0.001	0.020	53	0.006	0.019	53	0.2	0.7	53	0.002	0.011	53	0.01	0.03
1987	59	0.001	0.007	59	0.008	0.020	60	0.1	0.5	59	0.006	0.010	59	0.01	0.04
12051															
1986	30	0.002	0.018	30	0.006	0.038	30	0.1	0.4	30	0.002	0.015	30	0.01	0.02
1987	56	0.001	0.006	56	0.007	0.020	56	0.1	0.4	56	0.006	0.010	56	0.01	0.04

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Manganese			Iron			Nitrate			Sulphate			Chloride		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12002															
1981	55	0.06	0.20	55	1.8	6.9	58	7.0	19.4	57	13.1	29.7			
1982	51	0.05	0.11	49	1.4	4.2	45	5.4	15.6	51	11.2	37.4			
1983	33	0.04	0.11	33	1.3	3.0	54	4.8	14.5	54	9.7	27.5			
1984	34	0.06	0.14	34	1.4	3.9	57	4.1	10.8	57	9.5	25.5			
1985	57	0.07	0.51	57	1.2	4.0	57	4.5	10.3	57	9.5	32.7			
1986	55	0.05	0.17	55	1.2	3.8	55	4.5	12.3	55	11.4	31.4			
1987	56	0.07	0.20	56	1.9	6.8	51	5.3	13.o	56	12.2	34.3			
12005															
1981	50	0.04	0.34	59	1.2	13.0	59	4.9	11.1	58	10.6	28.8			
1982	53	0.03	0.10	49	0.7	2.7	44	4.0	10.1	48	10.5	34.3			
1983	52	0.03	0.11	52	0.8	2.5	52	3.6	11.0	52	9.3	29.6			
1984	52	0.04	0.40	53	0.8	2.5	53	4.0	9.2	53	9.3	21.7			
1985	59	0.04	0.16	59	0.9	5.2	59	4.4	9.0	59	9.3	32.9			
1986	52	0.04	0.18	52	0.9	2.9	52	4.3	12.3	52	10.1	26.0			
1987	60	0.04	0.16	60	1.1	3.5	55	4.7	10.2	60	10.7	31.2			
12007															
1986				33	2.0	5.9									
1987				51	3.5	13.7							51	2.0	5.8
12008															
1981	307	0.06	0.25	307	1.6	7.2	305	4.9	19.8	297	10.4	44.5			
1982	319	0.04	0.23	295	1.2	5.4	267	4.6	17.3	268	10.4	50.5			
1983	328	0.04	0.17	328	1.2	5.5	328	4.0	13.2	328	9.5	41.7			
1984	344	0.06	0.37	344	1.5	5.9	344	4.5	17.4	332	8.9	28.7			
1985	325	0.08	2.50	325	1.5	5.2	325	4.8	22.7	325	10.4	39.8			
1986	313	0.06	0.50	313	1.9	17.0	313	5.7	23.9	313	12.1	44.3			
1987	304	0.08	0.38	304	2.1	10.5	304	6.5	31.7	304	13.9	91.9			

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Manganese			Iron			Nitrate			Sulphate			Chloride		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12009															
1981							55	5.3	17.5	55	11.6	24.6			
1982							43	4.5	13.7	41	10.2	26.4			
1983							53	4.1	12.7	53	10.6	32.4			
1984							55	4.1	12.0	55	9.1	20.3			
1985							55	4.2	9.9	55	9.0	30.5			
1986							56	3.8	13.1	56	8.5	30.7			
1987							59	5.4	18.0	59	10.4	22.7			
12010															
1981	55	0.04	0.42	55	0.9	4.4	58	4.5	14.3	58	11.1	36.4			
1982	56	0.02	0.09	52	0.5	1.8	56	3.1	9.7	56	8.8	19.8			
1983	33	0.02	0.04	33	0.5	1.4	33	3.2	10.3	33	8.2	19.3			
1984	32	0.02	0.05	32	0.4	1.0	32	2.9	11.2	32	9.1	24.6			
1985	58	0.04	0.17	58	0.8	5.1	58	3.8	12.2	58	9.1	33.5			
1986	54	0.04	0.20	54	1.1	4.2	54	4.4	12.9	54	10.4	33.7			
1987	52	0.03	0.10	52	0.8	2.7	52	5.2	13.7	52	11.3	30.7			
12013															
1981	53	0.06	0.20	56	1.8	6.4									
1982	56	0.15	0.92	53	2.6	8.3									
1983	56	0.15	1.14	56	3.2	16.									
1984	58	0.15	0.83	58	3.9	22.2									
1985	57	0.19	1.14	57	3.6	14.2									
1986	60	0.17	1.05	60	3.5	15.5									
1987	58	0.22	0.91	58	6.4	45.9									
12015															
1981	52	0.08	0.22	57	2.5	5.8	55	6.0	17.3	55	14.3	32.3			
1982	52	0.05	0.15	52	2.1	27.1	51	4.6	15.1	51	11.7	28.0			
1983	57	0.06	0.14	57	1.8	6.4	43	4.5	13.8	43	10.8	27.5			
1984	47	0.09	0.27	47	2.5	8.0	47	5.7	14.3	47	13.7	40.6	49	3.6	21.5
1985	58	0.11	0.30	58	3.0	9.6	58	6.0	22.9	58	13.6	34.1	58	6.5	34.4
1986	53	0.08	0.23	53	2.2	7.4	53	4.9	12.2	53	11.6	27.2	53	3.3	18.6
1987	53	0.11	0.34	53	3.5	13.2	53	5.9	17.0	53	13.4	35.9	53	4.1	23.5

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Manganese			Iron			Nitrate			Sulphate			Chloride		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12016															
1981				10	1.7	3.3									
1982				54	1.5	6.3									
1983				73	1.5	4.0									
1984				120	1.4	6.0									
1985				116	1.5	4.7									
1986				71	2.7	12.4									
1987				59	2.5	11.2									
12038															
1985	39	0.11	0.41	39	7.3	35.1									
1986	56	0.06	0.29	54	7.0	46.0	56	3.6	11.4	56	7.5	25.2	56	1.0	7.1
1987	54	0.12	0.47	54	7.5	42.5	54	4.9	13.1	54	10.5	27.7	55	1.5	8.2
12039															
1981				59	1.8	10.4									
1982				52	1.5	12.4									
1983				58	2.6	14.0									
1984				56	2.3	24.8									
1985				65	1.9	10.3									
1986	56	0.05	0.20	56	1.8	8.7	56	4.8	14.3	56	10.1	27.7	56	1.4	11.1
1987	60	0.07	0.17	60	2.5	8.4	60	5.4	15.3	60	12.5	39.2	60	1.8	13.9
12047															
1985	52	0.05	0.14	52	1.6	11.2									
1986	52	0.04	0.38	52	1.2	5.4	52	3.9	10.1	52	7.8	25.4	52	0.7	4.8
1987	50	0.03	0.14	50	1.5	4.2	50	5.2	14.7	52	11.5	35.8	50	1.1	5.0
12049															
1985	62	0.06	0.19	62	2.3	14.2									
1986	53	0.04	0.15	53	1.6	4.4	53	4.0	14.6	53	8.0	24.3	53	0.6	4.3
1987	59	0.06	0.20	59	2.2	10.8	59	4.6	14.6	59	10.9	37.3	59	1.0	4.1

Table A4 Summary of Constituents in Suspended Particulate Matter (ug/m^3) Continued

Station and Year	Manganese			Iron			Nitrate			Sulphate			Chloride		
	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.	# of Samples	Avg.	Max.
12051															
1986	30	0.05	0.12	30	2.1	6.5	30	3.6	13.4	30	7.5	17.0	30	0.7	3.0
1987	56	0.06	0.14	56	2.5	8.3	56	4.3	12.3	56	9.3	33.2	56	1.0	3.9

APPENDIX 3

TOTAL REDUCED SULPHUR, CARBON MONOXIDE, OXIDES OF NITROGEN, HYDROCARBONS AND OZONE

Table A5. Summary of data for total reduced sulphur, carbon monoxide, oxides of nitrogen, hydrocarbons and ozone.

Parameter	1987	1986	1985	1984	1983	1982	1981	1980
Station 12008								
Carbon monoxide								
Annual average (ppm)	1	1	1	1	1	1	1	2
Percentage of values greater than:								
1-hour criterion	0	0	0	0	0	0	0	0
8-hour criterion	0	0	0	0	0	0	0	0
Nitrogen dioxide								
Annual average (ppm)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Percentage of values greater than:								
1-hour criterion	0	0	0	0	0	0	0	0
24-hour criterion	0	0	0	0	0	0	0	0
Nitric oxide								
Annual average (ppm)	0.01	0.02	0.02	0.03	0.02	0.01	0.02	0.02
Total oxides of nitrogen								
Annual average (ppm)	0.04	0.04	0.04	0.05	0.04	0.04	0.05	0.05
Total hydrocarbons								
Annual average (ppm)	2.3	2.2	2.1	2.3	2.1	2.1	2.1	2.2
Reactive hydrocarbons								
Annual average	0.4	0.3	0.4	0.4	0.3	0.4	0.4	
Ozone								
Annual average (ppm)	0.018	0.017	0.020	0.019	0.019	0.018	0.019	0.020
Percentage of values greater than 1-hour criterion	0.8	0.5	0.9	1.7	1.4	0.6	1.3	1.8

Table A5. Continued

Parameter	1987	1986	1985	1984	1983	1982	1981	1980
Station 12007								
Total reduced sulphur			(a)					
Annual average (ppb)	2.1	2.0	2.0	1.3				
Percentage of values greater than:								
1-hour criterion	2.06	2.04	0.79	0.70				
Station 12013								
Total reduced sulphur			(a)					
Annual average (ppb)	0.4	0.3	1.4	1.5				
Percentage of values greater than:								
1-hour criterion	0.00	0.00	0.00	0.00				

(a) 7 months of data